MILL SECTION of

Concrete

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Some Recent Research in the Art of Fine Grinding

Some Results of a Study Made by the British Portland Cement Research Association Between 1923 and 1925—Importance of Fine Grinding—Tabulations of Results—Power Required—Efficiency of Grinding Machines—Discussion of Sizes and Shapes of Ground Material

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THE work detailed below was carried out between 1922 and July, 1925, and establishes the right of grinding to rank as an exact mechanical science, with her own laws and methods of calculation, as definite as those appertaining to electricity or steam. In other words, just as the engineer knows the amount of electrical energy or steam necessary to perform a given amount of work under definite conditions, a development of this research would enable one in future to estimate the theoretical amount of work required to reduce a given material to a given degree of fineness under given conditions. It will thus be possible to deduce the efficiency of any grinding machine.

The importance of this development in the gold-mining, pigment, cement, ceramic, and other industries—which depend so largely upon the economical production of materials in a state of fine division—will be apparent when we reflect on the great advances which occurred in the sciences of electrical and steam engineering, when the underlying laws were discovered.

The work was carried out under most worrying and discouraging circumstances. The Government withdrew their grant long before the British Portland Cement Research Association was on its feet, while the cement trade itself was openly hostile. This was all the more remarkable because the cost of grinding the 4,000,000 tons of cement annually produced in the United Kingdom must run to well over £1,000,000 annually. When we consider the enormous sums of money spent on grinding not only by the cement industry but also by other industries as well, such as mining, metallurgical, coal, pigment, fertilizer, cereal, explosives, and others too numerous to mention, to all of which the subject was of vital importance, it is curious that no effort was made by any of the interested trades to help or encourage the work.

The following is a brief summary of a few of the results obtained, using pure quartz sand as the easiest substance to work with, since it is a nearly chemically pure, brittle, crystalline substance, which can be cheaply obtained in unlimited amounts and whose surface can be accurately measured by chemical means.

Law I. (Rittinger's law.) *The surface produced is accurately proportional to the work done. Double the work and the surface produced is doubled. Treble the work and the surface produced is trebled.*

The law was originally guessed at by von Rittinger in 1867 but, so far as I am aware, was first proved rigorously between 1924 and 1925 when actual measurements of the surface of powdered quartz by a chemical method and of the horse power required to powder it were made by the British Portland Cement Research Association.

The following were the results obtained in a small experimental tube mill using 1-in. steel balls.

Work done ft.-lb.	Increase in sand surface sq. ft.	Work required to increase surface by 1 sq. ft. ft. lb.
243,375	3971	61.3
470,250	7852	59.9
699,190	11,170	62.6
892,346	14,941	59.7
1,097,300	17,899	61.3

It would be very interesting to carry out experiments in grinding common salt or ice or some similar pure chemical so as to confirm this law in the case of other crystalline substances. Absolute surface determinations could be made in these cases by measuring their rate of dissolution in different media.

The physical basis of Rittinger's law is the constant molecular attraction which holds together the particles composing any chemically pure, brittle crystalline substance. In dividing the crystals work is being done against a constant force.

In the liquid state of matter a similar law holds. The surface tension of a pure liquid is a constant. Hence when a liquid film is extended (as in blowing a soap bubble) the work done is proportional to the surface produced.

As the result of these experiments it is a simple matter to calculate the work required in grinding to any requisite degree of fineness with any given grinding media.

$W = B(S_2 - S_1)$ ft.-lb. ——————————(1)

where W = the work required in ft.-lb.

S_2 = final surface of powder in sq. ft.

S_1 = original surface of powder in sq. ft.

B = a constant peculiar to the grinding medium employed, the material ground, and the type of grinding machine employed, being the work required to increase the surface by one square foot.

Using 1-in. steel balls in the 18-in. mill for quartz sand, B was found to be 60.9 ft.-lb.

Example. Calculate the power required to grind per hour 3 tons of quartz sand from a fineness represented by 24.3 sq. ft. per lb. (Leighton Buzzard standard cement sand—20^2+30^2 cement sieve) to a fineness represented by 827 sq. ft. per lb. (corresponding to 1% on the 200 I.M.M. sieve), using 1-in. steel balls in an 18-in.×18-in. mill. 3 tons=6720 lb.

Final surface $S_2 = 6720 \times 827 = 5{,}558{,}000$ sq. feet.

Initial surface $S_1 = 6720 \times 24.3 = 163{,}300$.

Constant B=60.9 ft.-lb. Hence employing formula (1)

W=60.9 (5,558,000—163,300) =328,600,000 ft.-lb.

1 horse-power = 33,000 ft.-lb. of work per minute.

= 1,980,000 ft.-lb. of work per hour.

Hence theoretical horse-power required for grinding 3 tons per hour is 328,600,000÷1,980,000=166 h.p.

Connection between the work required in grinding and the total heat required to volatilize a substance.

The subject is of great scientific interest. For example, there is an obvious thermodynamical connection between the work done in grinding (*i.e.*, producing small particles from large ones) and the amount of heat required theoretically to gasify the material. For—considering the simplest possible case—in gasifying a homogeneous solid material (without passing through the intermediate liquid state) the material is merely being reduced to particles of molecular dimensions, whereas in ordinary grinding the same action is performed, but the particles remain of considerable size. It follows from this that a homogeneous crystalline substance such as the diamond (which requires a large amount of heat and a high temperature to gasify) would be expected to require the expenditure of much energy in reducing it to a fine state of division, whereas a substance like ice (if reduced to an equally fine powder at a temperature below the freezing point of water) would require much less work to divide into smaller particles. This aspect obviously opens out a large field of research until now quite untouched; for example, there exists a large number of organic crystalline compounds of known heats of volatilization, the action of which under percussion or pressure could be investigated from this point of view. Again, it is not without significance that most organic compounds are soft, and do not require much force to separate one particle from another, and at the same time are in general easy to gasify, whereas minerals and metals in general require great power to separate into individual particles, and at the same time only become gaseous at high temperatures.

Absolute Efficiency of Grinding Machines

The absolute efficiency of a grinding machine can be deduced by grinding brittle crystals of known heat of volatilization.

The following calculation is interesting. Imagine quartz sand to be continually ground until reduced to particles the size of molecules. Then the work required to produce this result is the same as the work required to convert the silica into a gas (where each molecule is separated from the other). So that the work of grinding will be the same as the work required to volatilize the substance. From Bragg and Milligan's recent work we may calculate the surface exposed by 1 lb. of silica molecules as 38×10^6 sq. ft. From Trouton's rule we may calculate the latent heat of evaporation of silica is 1765 B.t.u. per lb., so that the work required to gasify 1 lb. of silica is $1765 \times 778 = 1.4 \times 10^6$ ft. lb. So that to increase the surface by 1 sq. foot requires $(1.4 \times 10^6) \div (38 \times 10^6) = 1/27$ ft.-lb. The value required in practice with 1-in. steel balls is 60 ft.-lb. Hence the efficiency of a modern tube-mill is only $1/27 \times 100 \div 60 = 1/16\%$. We thus have still a long way to go in making grinding machines efficient.

It would be interesting to grind salt, ice or certain pure chemicals of known heat of volatilization and see whether the same machine has the same efficiency when grinding different crystalline substances. The use of sieves is far too coarse a method for judging of the efficiency of a grinding machine, and they are useless for very fine grinding as the bulk of surface produced lies below the 200-mesh sieve.

The grinding efficiency should be measured in terms of the work in ft.-lb. required to increase the surface of a standard quartz sand by 1 square foot.

This can be accurately done now by methods I have detailed elsewhere.*

At the present time the same types of machine give most discordant data *e.g.*, in one cement works I found by actual measurement that 1 ton of cement an hour requires the expenditure of 115 h.p. to grind to 5% on 180×180 sieve, while in another I was assured by the engineer that only 35 h.p. was required to perform this work, and in another only 20 h.p.

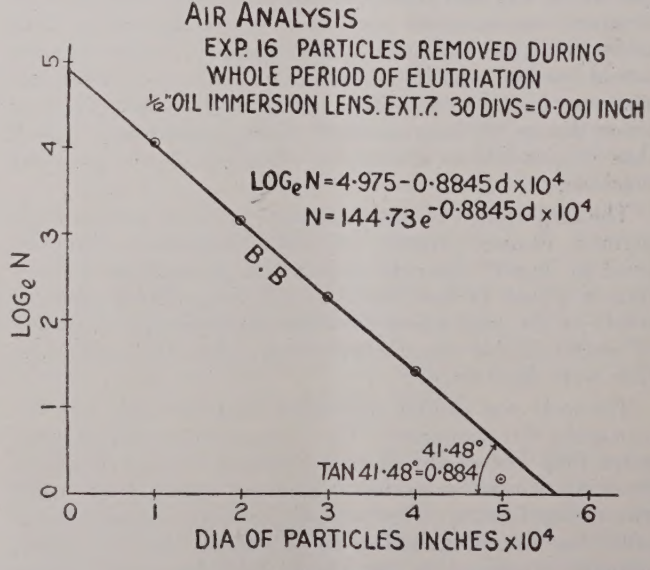


Fig. 1

Law 2. The number of particles produced increases with decreasing diameter, according to the compound interest law.†

In other words, the number of particles grow with in-

creasing fineness in the same way that money grows when let out at compound interest.

Mathematically the law may be stated thus:—

In a given weight of finely crushed sand, if N be the number of particles of diameter x, and if N and x be considered as variables, then in every case so far tested:

$$-N = a e^{-bx} \qquad (3)$$

where a and b are two constants characteristic of the particular sample treated.

Differentiating (3) we obtain:—

$$dN/ = -b\,a\,e^{-bx} = -b\,N \qquad (4).$$

In other words, the rate of increase with decrease of diameter in the number of particles of a given degree of fineness is proportional to the number already present of that particular degree of fineness.

If we take logarithms of (3) we get

$$\text{Log}_e N = \log_e a - b\,x.$$

So that if we plot the logarithms of the numbers against diameters we obtain a straight line.

The following represent some typical results:—

d. mean diam. of particles inches	Experimental value of N	Calculated values of N from formula	Ratio of successive ordinates $N_n/N_{n'}$
1×10^{-4}	54.152	53.592	2.157
2×10^{-4}	24.944	24.849	2.157
3×10^{-4}	11.408	11.522	2.157
4×10^{-4}	5.130	5.342	2.15
5×10^{-4}	2.637	2.474	2.15
6×10^{-4}	1.283	1.1485	2.157
7×10^{-4}	0.446	0.5325	
	100.000		

Fig. 1 shows a typical straight line produced when the logarithms of the numbers are plotted against the diameters:—

The physical significance of this is simple. Consider a set of sand particles A (Fig. 2). By grinding, each of the particles A gives rise to the same number k (in the illustration $k = 2$) of smaller particles B, which in their turn give rise each one to the same number k of still smaller particles C, and so on all down the scale so far as we can pursue the matter by means of the microscope, with the ultimate production of colloidal particles.

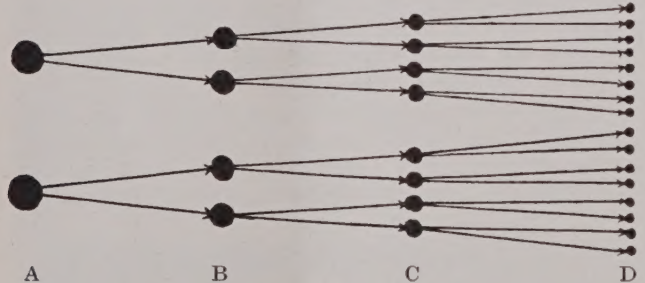


FIG. 2.

The law is probably the expression of the fact that crystals have a definite and fixed structure, and consequently break up when subjected to percussion or pressure in a regular and definite manner which follows a definite mathematical law when the number of particles considered is sufficiently large to allow of the application of the law of probability. It is possibly a necessary consequence of Rittinger's law.

Law 3. The average shape of the particles produced in crushing remains the same whether they are large or small.

This was proved by grading out the crushed quartz sand by elaborate air-elutriation experiments, and then proceeding to measure the absolute diameter, surface, weight, and number of the particles in each grade. The result was confirmed by plotting against the diameters the terminal speeds obtained when particles of sand of different diameters were allowed to fall in air at a constant temperature. Both the small and the large particles occurred on the same straight line, which would not have been the case if their shapes had differed.

If S be the statistical surface of the particles of statistical diameter d, then $S/d^2 =$ constant A, no matter whether the particles are of large or small size. This constant, A, we propose to call the "surface constant."

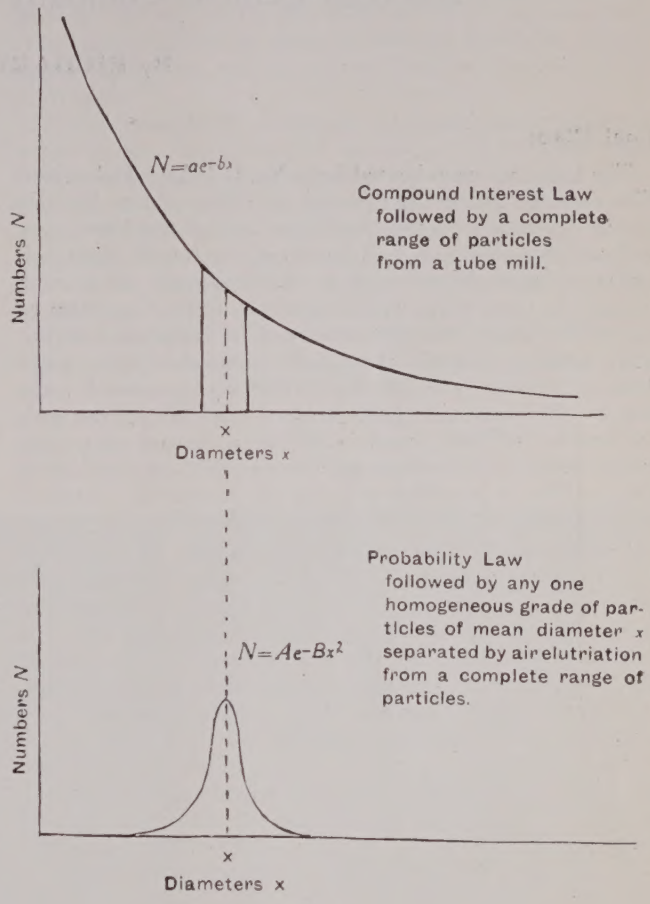

$N=ae^{-bx}$
Compound Interest Law followed by a complete range of particles from a tube mill.
Numbers N
Diameters x
Probability Law followed by any one homogeneous grade of particles of mean diameter x separated by air elutriation from a complete range of particles.
$N=Ae^{-Bx^2}$
Numbers N
Diameters x

Fig. 3

The following table represents the results obtained from crushed sand. The variations from constancy are within the limits of experimental error when the extreme difficulties of the determination are considered. It is shown that

Sample of quartz	Arithmetical mean. diam. cm.	No. of particles per gram of sample	Abs. surface of 1 g. sq. cm.	Surface constant A.
A. E. 1A	0.00333	31,426,800	791	2.14
" 1	0.00401	16,705,650	584	2.01
" 2	0.00459	11,296,900	508	1.98
" 3	0.00513	8,486,100	496	2.10
" 4	0.00551	7,181,850	443	1.95
" 5	0.00593	5,676,650	414	1.98
" 6	0.00673	3,846,150	367	2.01
" 7	0.00753	2,779,800	334	2.03
" 8	0.00895	1,650,000	315	2.27
" 9	0.00928	1,469,300	292	2.20
" 10	0.01089	889,050	244	2.21
" 11	0.01305	522,300	221	2.35
" 12	0.01551	323,300	187	2.29

for sand particles ground in a tube mill, and of statistical diameters ranging from 0.00333 cm. to 0.01089 cm. this surface constant is about 2.

In other words, if the statistical diameter of a particle be d cm., the statistical surface of this particle will be $2\,d^2$ cm.

Law 4. Any grade of crushed sand coming from a tube-

(Concluded on page 110)

New Canadian Cement Plant

PART II

The Conclusion of a Description of the Plant of the National Cement Company in Montreal

By RICHARD K. MEADE

Coal Plant

The kilns are each heated by a No. G-1 Aero Pulverizer. This machine pulverizes the coal and blows it into the kiln in one operation. These machines are of the latest type and are provided with ball bearings. A fourth Aero pulverizer is mounted on a truck which operates on a track behind the three main pulverizers. In case of accident to any of the latter, this pulverizer can be installed with but a few minutes' delay by means of a removable pipe. Each Aero is driven by a 100-h.p., 1200 r.p.m. wound rotor motor. There is an I-beam trolley track above the pulverizers to facilitate repairs. As the principal parts subject to wear and breakage are the paddles, an extra rotor with paddles is provided and this can be quickly installed at any time by means of the I-beam and trolley.

The coal for burning is handled by means of equipment furnished by the Canadian-Meade-Morrison Company and storage is provided for 30,000 tons of coal. The cars are dumped into a pit, a belt feeder empties this into the boot of an elevator with two discharge chutes—one of which deposits it on a pile across the railroad track. A drag line and scraper outfit operated by a 60-h.p. squirrel cage motor carries it from this pile and distributes it over the whole area of the coal storage (a semicircle of about 300 ft. radius). This same drag line and scraper is used to reclaim the coal, dragging it back into the track hopper. From this hopper it goes to the elevator when the second spout discharges it into a concrete hopper. The latter is equipped with a belt feeder, which delivers the coal regularly to a 36x24-in. Pennsylvania single roll coal crusher. This same arrangement of elevator and feeder may be used to send coal directly from the cars to the crusher without its going into storage. The coal crusher in turn discharges into the boot of an inclined 18x18x8½-in. bucket elevator. This elevator carries the coal up and discharges it into a 6x70-ft. rotary dryer.

The coal dryer is direct fired by means of grates. It is so arranged, however, that ample space is given for the combustion to be completed before the gases from the fire pass into the cylinder. Damper doors are also arranged to be operated by a thermostatic control. These introduce air at the side of the dryer and keep the gases going into the cylinder below the temperature at which coal ignites. This dryer is designed for use only in wet weather and when the coal is received at the plant or reclaimed full of snow and ice. It will need to be used only on such occasions, as the Aero pulverizers will handle coal containing up to 10 per cent moisture.

Clinker Storage

The clinker is conveyed from the kilns by means of three "Rex" drag chains furnished by the Chain Belt Company, Milwaukee, which operate in troughs lined with chilled iron plates. These conveyors are so arranged that clinker from the kiln on either side may be discharged to them allowing one to be cut out for repairs if desired.

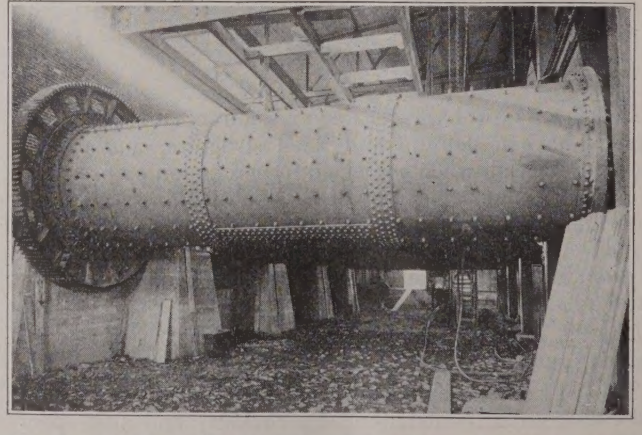
These drag conveyors carry the material up a slight incline and over a wall into the clinker storage, from which point the distribution is made by means of a 5-ton Shephard crane handling a 2-yd. Hayward bucket. This crane has a span of 100 ft. and the length of the clinker storage is 240 ft. The storage has a capacity of 250,000 bbl. of clinker. The crane was furnished by the Shepherd Electric & Manufacturing Company, Montour Falls, N. Y.

The reclaimed clinker is discharged by the crane into a concrete hopper above a 6x70-ft. dryer. The function of the latter is partly that of a conveyor and it may also be used to dry seasoned clinker, which has become wet or in certain seasons of the year is mixed with snow and ice. The drying is done by mixing hot and cold clinker together, the hot clinker serving to dry the seasoned clinker by means of the heat of the former.

The clinker falls from this dryer into automatic scales which weigh the latter and which also operate a small scale, or rather measuring device, which adds the proper quantity of crushed gypsum. The scales and measuring device are of the rotating drum type and were designed by the engineer.

The gypsum is received at the plant in box cars and crushed to 1 in. It is discharged from these into a concrete pit which in turn discharges into the boot of a bucket elevator. This latter elevates the gypsum into storage. The storage consists of a reinforced concrete silo 15 ft. in diameter by 45 ft. high. It is fed directly through an opening in the bottom of this silo into the hopper above the gypsum scales as needed.

Both the clinker and gypsum scales discharge onto a 24-in. belt conveyor, which in turn discharges into the boot of a bucket elevator. This and a drag chain similar to that used for the raw material are used to place the clinker in



Canadian Vickers—Meade tube mills. Note the beams for a platform above the mills to facilitate charging

the bins above the Hercules mills. The ground cement is conveyed from the finishing mill to the stock house by means of the Fuller-Kinyon system.

Stock and Pack House

The stockhouse of the National Cement Company consists of ten reinforced concrete silos 25 ft. in diameter by 75 ft. high, with interspaced bins, all holding approximately 110,000 barrels of cement. These bins are constructed with hopper bottoms and can be emptied very completely. They discharge into two screw conveyors situated in tunnels beneath the silos. The Fuller-Kinyon system was not employed here because this stockhouse was one of the first buildings of the plant completed and at the time it was built this system had not been employed to any extent for cement.

The cement is elevated into bins and sacked as usual by Bates valve bag machines. Loading tracks are provided on each side of the packing house. The second story of the latter is used for sorting and cleaning the bags, the latter being done by means of the ordinary cleaning wheel. The bags are elevated to the second story by a bag elevator, and after cleaning and sorting are dropped through chutes to the racks at the side of the bagging machine. Tracks for packing run on each side of the pack house and trucks are loaded from the rear.

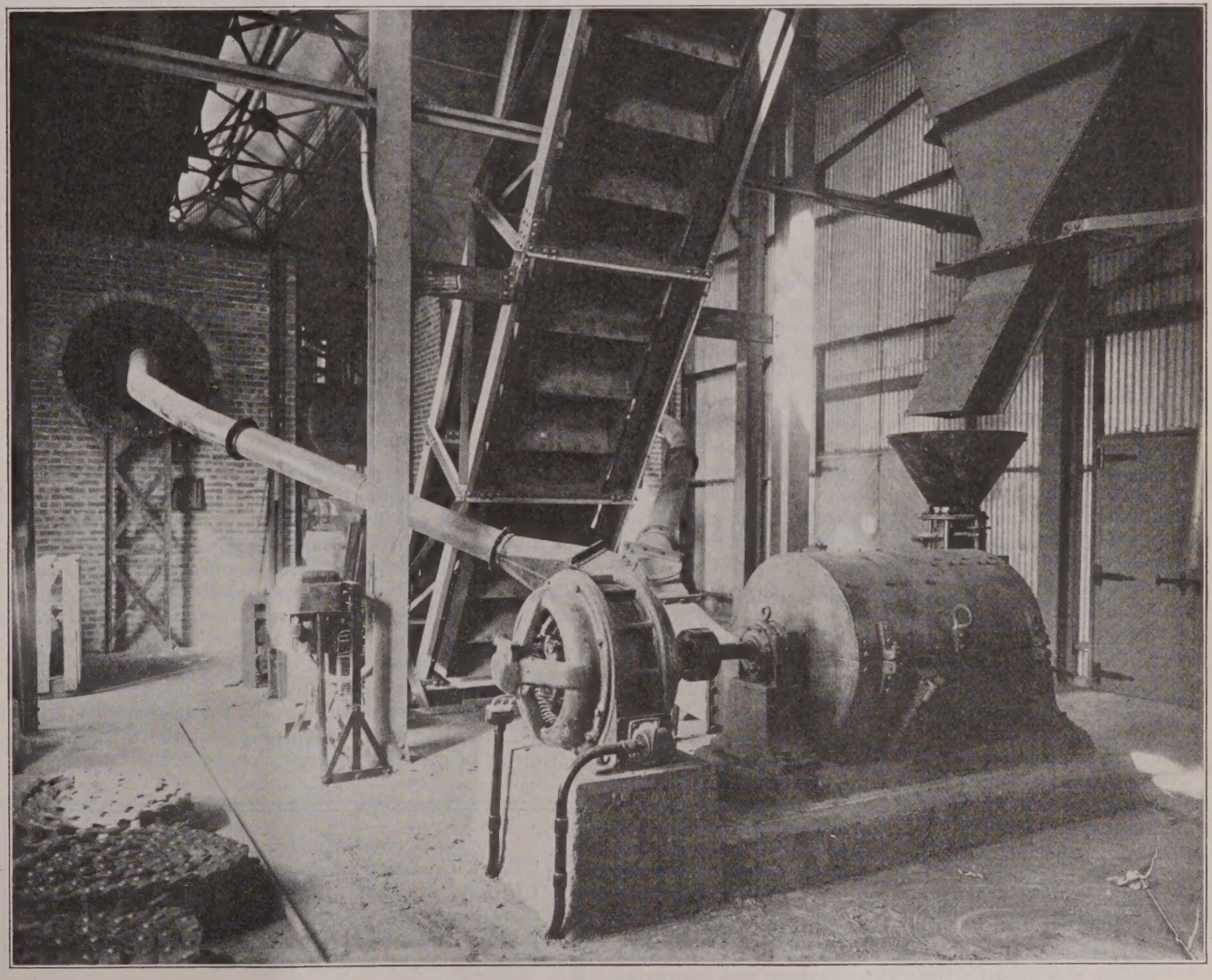
The engineer's plans call for a fireproof bag storage 67x55 ft. of reinforced concrete and tile with a concrete roof, in which return bags after cleaning and tying will be stored. This storage is to be cut up by tile partitions into twelve vaults to minimize loss should fire occur among the bags.

Electrical Equipment

All the motors in the plant were furnished by the Canadian General Electric Company of Toronto. The motor in the crushing plant and in the raw and clinker mill and on the Aero pulverizers are operated with 2200 volts, 3-phase, 60-cycle current, while 550 volts are employed elsewhere in the plant. All of the large motors are, therefore, operating at 2200 volts and all of the main power line are at 2200 volts.

Where possible all machinery has been direct connected to the motor. In the case of elevators and conveyors De-Laval worm gear reducers have been used. Outside of the primary crusher there are practically no belt drives in the plant. Hydro-electric power is purchased from the Montreal Light Heat & Power Company at a figure which does not make a waste heat boiler installation attractive. The incoming power lines are at 12,100 volts.

The sub-station is of reinforced concrete and is located adjacent to the crushing plant, grinding mill and kiln room where the major portion of the power is used. A glance at the plan will show how short the leads are to the principal motors. It will be noted that the sub-station is divided into four rooms separated by reinforced con-



Aero coal pulverizer installation. The elevator from the dryers to the stone house can be seen in the center of the illustration. This type of elevator is used for crushed stone throughout the mill

crete partitions. The incoming lines enter at the west side and are protected by aluminum oxide lightning arresters. There are two 400-ampere, 15,000-volt circuit-breakers. At the south end are located three 12,100/2200-volt, 1667 Kva. transformers and at the north end three 12,100/557-volt, 333 Kva. transformers. Roll steel doors provide a means of withdrawing the transformers from the building if desired. Seven feeder panels equipped with the usual indicating and recording instruments distribute the 2200-volt current by underground conduits to the various large motors, while five similar panels distribute the 550-volt current to the small motors. The motors are arranged in twelve groups and all the motors in any group can be stopped by means of push buttons located at strategic points convenient to the operator. A 60 Kva. 2300/115/230-volt lighting transformer is provided for the lighting of the mill, shops, offices, etc. The Chase Electric Company, Fall River, Mass., were the contractors for installing the electrical equipment.

Miscellaneous Equipment

The air compressor room is located in the end bay of the crushing plant. The equipment consists of one compound 16 and 10x12-in. and one single stage 14x12-in. Canadian Ingersoll-Rand air compressors—both motor-driven. These furnish air for the jack-hammer drills in the quarry, for the Fuller-Kinyon pumps and for blowing off the motors, etc.

The mill buildings and bins with the exception as noted of the shops, the stone storage, blending bins, gypsum and cement silos and sub-station are of steel with corrugated roofing and siding. The mill building has a gypsum roof. All pits are waterproofed with hydrated lime or some appropriate compound and all concrete and gypsum roofs are covered with tar. Floors are of concrete. The crusher building is 30x80 ft., the dryer building 30x135 ft., the mill building 92x96 ft., the building at the feed end of the kiln is 60x29 ft. and that at the discharge end 60x39 ft. The pack house is 65x66 ft.

The machine shop, storehouse, lavatory and washroom, superintendent's office, electrician's shop, laboratory and plant office are all located in a one-story reinforced concrete building, 255x30 ft., with continuous steel sash and gypsum roof. This building is heated by its own steam plant, which is located in a basement at the south end. The physical laboratory is also located in this basement.

The machine shop is provided with a crane-way and is equipped with all machine tools necessary to make the ordinary repairs. The chemical laboratory is equipped with the latest appliances for testing cement, including a Chainomatic balance and a complete plant for crushing and grinding cement materials. At a little later date, it is proposed to build a laboratory and office building which will provide greater shop and storage space in the present building.

The outside equipment of the plant consists of a 30-ton, 16x24-in. saddle tank, locomotive and a 12-ton, 40-ft. boom, McMiler double truck, 8-wheel travelling crane.

Personnel

The mill was designed by and built under the supervision of Richard K. Meade & Co., 10 West Chase Street, Baltimore, Md., Joah Etchells, resident engineer. This firm also prospected the property. The general contractors for the plant were Downing-Cook & Co., Montreal, William C. Atkinson, superintendent of construction. The steel was fabricated and erected by the Standard Steel Construction Company of Welland, Ont. The Canadian Vickers Company, Montreal, furnished the tube mills, elevator casings, steel stacks, etc., and the Pleissisville Foundry & Machine Company, Pleissisville, Ont., the elevating and conveying machinery, shafting, etc. The Dravo-Doyle Company, Philadelphia, furnished the worm gears and the Vulcan Iron Works, Wilkes-Barre, Pa., the kilns.

The executive personnel of the National Cement Company consists of Joseph Versailles, president; Donat Raymond, vice-president; Lucien Hamel, secretary and treasurer, and J. R. Lefebvre, general manager, all of 90 St. James Street, Montreal. The directors are Hon. G. A. Simard, Hon. J. M. Wilson, E. C. Vidricaire, L. H. Timmins, all of Montreal, and Richard K. Meade, of Baltimore, Md.

The operating personnel consists of W. R. Oglesby (formerly of Cementos Hidalgos, Mexico), superintendent; Joah Etchells (formerly of Richard K. Meade & Co.), chief engineer; Warren A. Wolf (formerly of the Giant Portland Cement Company), chief chemist, and Mr. L. Leopold formerly of the Dexter Portland Cement Company), mill foreman.

Correcting an Error.—In Part I of the article describing the plant of the National Cement Co., the address of the A. P. Green Fire Brick Co. was given as St. Louis. This was an error. The correct address is Mexico, Mo.

Wabash Company Equips New Kiln with Strenes Metal Lifters

Experiments made in the new mill of the Wabash Portland Cement Company at Osborn, Ohio, provide interesting comparisons on the performances of kilns equipped with lifters with those not so equipped. A 90-day test has shown that the kiln equipped with lifters turns out a more uniform small size clinker and that the pyrometer recording the temperatures for the lifter equipped kiln indicates a more uniform temperature than that of the kiln not equipped with lifters.

Kilns in the new Wabash plant are 145 ft. long. In one of them five rows of metal lifters, six in a row with alternate rows staggered, were placed in the first 30 ft. of kiln length on the feed end. The lifters are 4 ft. long and 18 in. wide, 12 in. of which constitutes the lifting area. As the kiln rotates, these lifters hold the slurry and tend to break it up so that the heat of the kiln is more effective. The tests showed that in the lifter equipped kiln the slurry was reduced to dust in the first 30 ft. of travel through the kiln, while in the other kiln it was necessary for the slurry to travel 50 ft. before it was completely dried out.

The metal lifters, subjected as they are to high temperatures, and to abrasion, had to be of a quality that could withstand heat and wear. In looking about for a material for this purpose, Mr. L. L. Stone, construction engineer of the plant, made use of a locally manufactured metal called Strenes metal. This metal was developed to offer a surface with a high resistance to abrasion and one that would hold its shape and strength under temperatures up to 1600 deg. F. It has proved entirely satisfactory in the 90-day tests at the Wabash plant.

The material has also been used for feed spouts, clinker spouts, retarding rings and linings for the finishing compartments of grinding mills.

Are you reading Dr. Bogue's articles on "The Constitution of Portland Cement Clinker"? They appear in the Regular Section each month. Part II is published on pages 27-31 of the Regular Section this month. They are important.

Cement Production in Spain

A Report of the U. S. Department of Commerce—Statistics of Cement Production—Number of Mills—Equipment Used—Types and Quantities of Cement Manufactured—Exports—Markets

By C. H. CUNNINGHAM
American Commercial Attache, Madrid, Spain

THERE is no Portland Manufacturers Association in Spain, and for that reason and because of the reserved character of Spanish national enterprises, it is very difficult to compile data on the portland cement industry in Spain. A table of statistics has been prepared, however, and reproduced in the "Ingenieria y Construccion" for November, 1925, based on data furnished by the Spanish factory directors themselves. This table accompanies this report and sets forth information obtained from replies to a questionnaire which asked: (1) The name of the company and the trade-mark for portland cement adopted by the company; (2) the dates of the establishment of the factories; (3) the methods of manufacture employed; (4) the system and number of ovens installed; and (5) the approximate daily and annual capacity in tons.

The fact that individualism in national industry in Spain is prevalent rather than union through associations, such as is usual in other countries, is no doubt largely the cause of the technical backwardness of Spanish industries. The distribution of the portland cement factories is a notable instance of this, there being twenty-one factories in all, most of which are grouped into three districts: Cataluna, Northern Spain and Central Spain. The others may be considered as isolated factories.

Mill Locations

In the accompanying table the Spanish factories of portland cement are arranged chronologically, the first being the Tudela-Veguin factory of Oviedo which, because of its nearness to important coal mines and its access to markets, is most excellently located. Shortly after the establishment of this factory, another was located in the Catalunian Pyrenees, which, with its three rotary ovens of 6 x 60 meters and its waterfall of 2000 horsepower, had a great producing capacity and was one of the most important factories in Europe in 1904. In 1909, this factory, the property of the Compania General de Asfaltos y Portland Asland, was enlarged by the addition of two ovens, each forty meters long, and from that time dates the development of the portland cement industry in Spain. Many factories were soon established throughout the country, although it should be stated that little care was exercised in the distribution of these factories, due to a lack of union among the companies interested in this industry.

Increase in Production

The following table shows the increase in the productive capacity of the Spanish factories since 1900:

Periods	Approximate amount produced (In Tons)
1900 to 1903	50,000
1904	100,000
1905 to 1909	150,000
1910	250,000
1911	350,000
1912	375,000
1913 to 1916	420,000
1917 to 1918	550,000
1919	580,000
1920	600,000
1921	730,000
1922	770,000
1923	900,000
1924	1,180,000
1925	1,320,000

The Compania General de Asfaltos y Portland Asland is at present the most important manufacturer of portland cement in Spain and owns, in addition to the above property, a factory in Moncada, Barcelona, which has the largest daily producing capacity of any factory in Spain, and has completed a third one in Villaluenga de la Sagra, Province of Toledo, which started production at the end of 1925.

One of the oldest factories and one most worthy of men-

STATISTICS OF THE PORTLAND CEMENT FACTORIES OF SPAIN, 1925.

Name of Company.	Mark.	Date of Inaugurat'n	Ovens and method of manufacture.	Capacity (in tons) Daily	Annual
Sdad. Anonima Tudela-Vegin Oviedo	Tudel a-Vegin portland extra	1898	4 rotary ovens (dry method)	200	60,000
Sdad. Aragonesa de Portland Artificial, Zaragoza	Fenix	1900	4 vertical ovens (two in reserve)	30	9,000
*Hijos de J. M. Rezola y Cia, S. en C. San Sebastian	Ancora	1901	Vertical ovens (?)	250	75,000
**C. G. de A. y P. Asland, Barcelona	Asland	1904	3 rotary ovens (dry method)	350	105,000
Cementos Portland, S. A., Pamplona	Cangrejo	1905	5 rotary ovens (originally dry method)	350	105,000
S. E. de Cementos Portland Hispania, Madrid	Hispania	1910	1 rotary oven (dry method)	180	30,000
Cia Anglo Espanola de Cementos Portland, Madrid	Leon	1911	2 rotary ovens (dry method)	200	60,000
Sdad. G. de Cementos Portland, de Sestac (Bilbao)	Hercules	1912	4 Candlot vertical ovens	60	18,000
Jose Fradera, Barcelona	Landfort	1913	3 rotary ovens (wet method)	450	135,000
Portland Iberia, Sociedad Anonima Castillejo, Toledo	Iberia	1914	2 rotary ovens (wet method)	200	60,000
C. G. de A. y P. Asland, Barcelona	Asland	1917	3 rotary ovens (dry method)	650	195,000
Sdad. Financiera y Minera, Malaga	Goliat	1921	3 vertical automatic ovens	180	54,000
La Auxiliar de Constuccion, Barcelona	Sanson	1921	2 rotary ovens (dry method)	400	120,000
Cia. Valenciana de Cementos Portland, Valencia	Raff	1922	4 vertical automatic ovens	150	45,000
Ziurrena, S. A., Bilbao	Ziurrena	1923	1 rotary oven (wet method)	100	30,000
S. A. Cementos Portland de Lemona, Bilbao	———	1923	1 rotary oven (wet method)	100	30,000
Sdad. Andaluza de Cementos Portland, Sevilla	El Caballo	1923	1 rotary oven (wet method)	115	34,500
Cia. de Comercio, S. A., Bilbao	Fama	1923	2 rotary ovens (dry method)	100	30,000
Cementos Cosmos, S. A., Madrid	Cosmos	1924	1 rotary oven (thick clay)	200	60,000
Portland Valderribas, C. M. A., Madrid	———	1925	1 rotary oven (wet method)	100	30,000
C. G. de A. y P. Asland, Barcelona	Asland	1925	1 rotary oven (dry method)	300	90,000

*Produces "semi-slow" natural cement; rapid natural cement marks, 3 and 3 anchors.
**First Spanish factory to produce white portland cement.

tion is that owned by the Sociedad Cementos Portland, S. A., of Pamplona, located at Olazagutia, which was established between 1903 and 1905 and has as its trademark "El Cangrejo."

The most recent factories established are those of Toral de los Vados in Leon, which has placed a high resistance cement on the market, and of Vivalvaro, which is still in a probationary state. All kinds of rotary ovens are used in the Spanish factories, but the use of thick clay is most general. This latter method is used by the Cosmos factory at Madrid.

Present Production

There are 33 rotary ovens used for the making of portland cement alone in Spain, three of which are mounted. The latter are 6x10 feet, or 1.8 by 3 meters in diameter and from 60 to 300 feet, or 18 to 60 meters long. The total annual production of all the Spanish factories is approximately seven million barrels. According to the annual report of the Spanish Mining Council, the production for 1924 was 681,689 tons of portland cement, against 504,727 tons for 1923, valued at 54,253,000 pesetas for 1924 against 35,242,000 pesetas for 1923. Production of natural cement for 1924 was 235,379 tons, valued at 5,516,076 pesetas against 358,627 tons for 1923, valued at 8,818,000 pesetas. At the present time, according to these official statistics, there are 23 portland cement factories operating in Spain, and 52 natural cement deposits. In the portland cement factories 19 units of hydraulic power are employed with a total force of 6,410 horsepower, 6 units of steam power with 2,875 horsepower, 9 units of internal combustion engines are employed with 1,297 horsepower, and 411 electric units are used with a total of 12,742 horsepower. Three thousand and ninety-six laborers are employed in the portland cement factories as against 1,053 in the natural cement installations. The latter have 22 units, producing 761 hydraulic horsepower, 7 steam units with 342 horsepower, 12 explosion engines with 360 horsepower, and 42 electric installations with 2,592 horsepower.

The progress of the cement industry in Spain from 1919 to 1924, inclusive, will be noted from the following table:

	Tons	Thousands of Pesetas
1919	363,461	18,260
1920	480,186	29,024
1921	540,338	31,198
1922	729,035	46,974
1923	863,354	44,060
1924	917,068	59,769

Market Conditions

It is believed that Spanish production will soon be sufficient for the national market of Spain, at least for the present, while the state is not in a condition to undertake new works or assist those already begun, excepting the program of highway construction, which is progressing systematically. When Spain becomes as interested in the construction and repair of her roads as other civilized countries, much more cement will be used. Considering the area of Spain as 505,000 square kilometers, it is estimated that there should be a consumption of two tons of cement to the square kilometer per year in road building alone. The building industry is always increasingly important in Spain, city enlargement plans being under way at Madrid, Barcelona, Sevilla, Valencia, and in fact, throughout the country. Towns are being converted into cities and villages into towns. External suburbs are being brought into the cities; new and modern streets are being surveyed and run through old cities; hundreds of old structures are being torn down; new ones are being built; and streets and avenues are being straightened and widened. There is a potential market in Spain for 2,000,000 tons of cement per year.

The importation of cement during the last three years was as follows:

	Tons	Value in pesetas
1922	18,775	2,253,024
1923	14,820	1,775,472
1924	15,766	1,892,004

Of the above, in the year 1924, the greatest quantity was imported from France, to the amount of 14,147 tons valued at 1,697,712 pesetas.

Electric Shovel Efficient in Cement Plant Quarry

Increased output in a shorter period of time, together with a reduction in labor, resulted from the installation of an electric shovel by the Cowell Portland Cement Co. at Cowell, California. This company had been using steam shovels in its quarrying operations, but on account of the obvious economies and the ease of operation, decided to purchase an electric shovel.

It was found that six cars could be loaded with the electric shovel while the steam shovel was loading five. The operator of the steam shovel was an experienced man, while the electric shovel was operated by a steam operator who had had no previous experience with electrical equipment. The dipper on the steam shovel had a capacity of 3 cu. yds., while the electric shovel had a dipper of but 1¾ cu. yds. capacity.

The electric shovel is a Marion model No. 37, the electrical equipment for which was furnished by the General Electric Co. Power is supplied from a 2300-volt transmission line running from the mill substation to the quarry where, by means of transformers, the voltage is stepped down to 440 and converted into direct current by the motor generator on the shovel.

In operating the steam shovel, nine men were required, including a shovel runner, a craneman, a fireman and six pit men. Only three men were needed for the electric shovel; an operator and two pit men.

There being no boiler required for the electric shovel, the replacement of tubes, and trouble from leaks, scaling, etc., were eliminated. A further saving was found by the elimination of a night watchman for keeping the boilers fired at night. Approximately three-fourths of the time necessary to move from one location to the next is saved by the electric shovel, as temporary roadbeds and tracks are unnecessary.

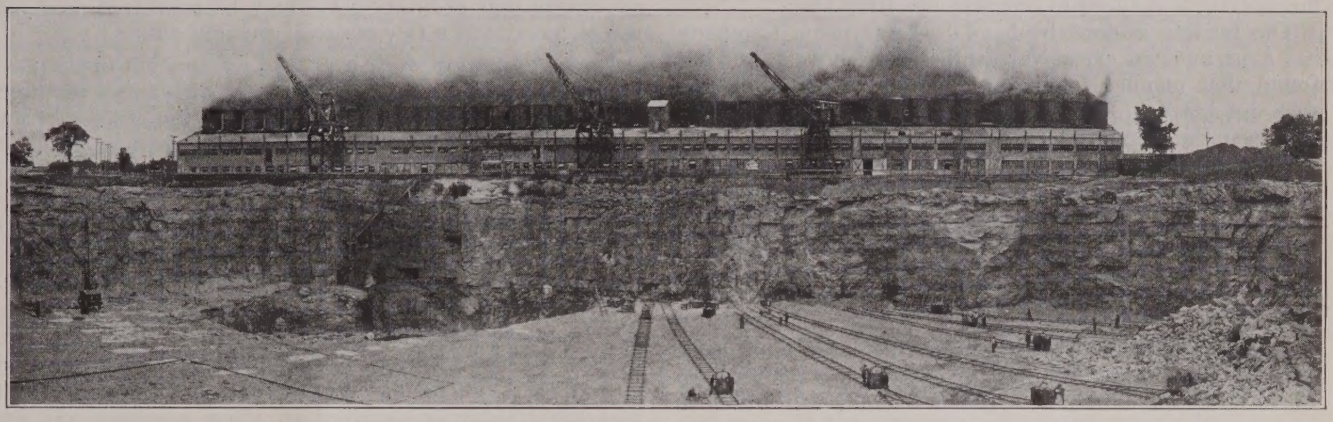
Cheaper Transport for Bauxite in France

June 1 marked the completion of the new Marseilles-Rove canal, which opens a waterway from Southern France to practically all points of France, as well as to most of Central Europe. Work has been under way for several years for nearly five miles of this canal consists of a 50-foot bore tunnel through the solid rock of the hills bordering the Etang de Berre.

Among those who will profit most from this new waterway are the various producers of Alumina Cement located in Central France. As practically all of the bauxite used by these concerns is produced along the Mediterannean coast and transported in its raw state to the cement mills it can readily be seen that this new waterway will provide a more rapid and economical method of transporting the bauxite. The La Farge company has already organized its own fleet of barges for the canal and a fleet of small schooners for service along the Mediterannean coast.

Lime Production at Genoa, Ohio

History—Analysis of Rock—U. S. Gypsum Company Plant—Quarry Operation—Two Product Operation in Plant



General view of the quarry and plant of the U. S. Gypsum Company at Genoa, Ohio

Genoa, Ohio, has been an important lime producing point for more than 50 years. The purity of the outcropping stone in this locality was recognized by the agricultural settlers. They burned it in a crude way. Slowly the good quality of the product created a more than local demand, which resulted in the abandonment of the rude kilns and the substitution of more extensive plants with facilities for modern and large-scale production.

Since 1915 the United States Gypsum Company has owned an important lime property at Genoa. The plant went into operation in 1916 and since has been enlarged five times. At present there are 40 shaft kilns in operation. These have a daily capacity of 500 tons of hydrate. Two rotary kilns have just been installed and will, when put in operation, increase the daily capacity about 50 per cent.

The principal product of the Genoa plant of the United States Gypsum Company is Ivory hydrated finishing lime. The high magnesium content—46 per cent—of the rock makes the Genoa finishing lime exceptional for whiteness and cool-working properties.

Geology

The United States Gypsum Company property is located on the upper beds of the Niagara lime. This deposit is widely distributed in Western and Northwestern Ohio. It is of great thickness, but the upper beds, which are composed of the true dolomite limestone, are the ones which possess the peculiar properties of purity and structure which make possible the white, cool-working hydrated lime.

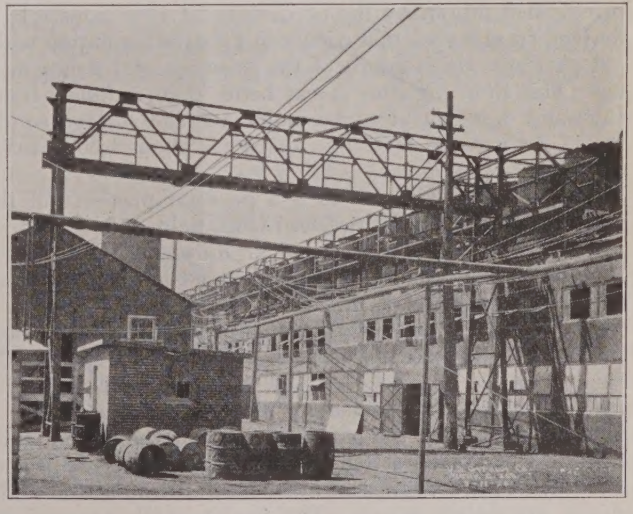
In 1914, before beginning construction of its plant, the Gypsum company had a test-hole put down in the middle of the property to the depth of 150 feet. By careful drilling, 98 per cent of the core of this hole was retained. Carefully sampled specimens of the core were submitted to Professor D. Hector Trowbridge of Lewis Institute, Chicago, and his analyses produced the following average result:

Carbonate of lime	54.78 per cent
Carbonate of magnesia	45.07 per cent
Iron and aluminum oxides	.72 per cent
Silica	.26 per cent

"The above analyses show," Dr. Trowbridge's report proceeded, "that this rock should not be classed as a limestone, or even a dolomitic limestone, but that it is a true dolomite, having a very small amount of impurities. An ideally pure dolomite would contain 54.7 of magnesium carbonate. Extensive deposits of this rock are rare in this country, so far as I am able to learn, and it is to be noted how even the results run for the entire 149 ft."

The company owns 115 acres of land, a half mile southeast of Genoa. The deposit at that point is known to be workable to a depth of 150 ft. Drilling to a depth of 225 ft. shows the same rock present there, but core-tests have not been made to a greater depth than those used for the analyses of Dr. Trowbridge. Estimates place the amount of rock contained in this property at, roughly, 50,000,000 tons.

In many places on this tract the rock is outcropping. At no point is the overburden so deep that it cannot be stripped by plows and hand-shoveled into wagons for removal.



Another view of the plant from the other side

Quarry Operation

At present the extent of the quarry is more than an acre. It is operated in two benches. Little difficulty from water has been encountered though, of course, pumps are kept on hand. Blast holes 5 in. in diameter are sunk from the surface by standard well-drilling apparatus. The holes are placed 12 ft. behind the edge of the pit and 12 ft. apart. Ingersoll-Rand air drills are used to make the "block holes," by means of which the rock, as blasted into the quarry, is reduced to one-man handling size.

The loading is done by hand. The Gypsum Company has experimented extensively with steam shovels, but has found that manual loading reduces the amount of fine rock not adaptable to the process of calcination. In consequence, the amount of road rock produced in the quarry has been kept down to 15 per cent of the total product.

The rock, loaded into narrow-gauge quarry-cars of ton-and-a-half capacity, is taken to the hoisting places by horse and is raised from the quarry to the kilns by means of gantry cranes. The gantry tracks run close to the edge of the pit and parallel to the lines of the kilns.

Plant Operation

In outline, the flow of the material from this point on is as follows: by crane into the kiln; drawn and cooled, and conveyed as quicklime to Williams hammer mill; then to Berquist hoppers: thence to Schaeffer hydrators; discharged into Raymond pulverizers; conveyed thence to the warehouse, where it is bagged and made ready for shipment.

One of the most important developments in the methods of producing hydrate at Genoa was the installation of a mechanical conveyor by which the quicklime is transported from the kilns to the crushers and at the same time is cooled. This marked a decided step forward in the handling of the material immediately after its removal from the kiln.

The two principal products at Genoa are hydrated finishing lime and mason's hydrate and the plant is so organized that half the mill can run on finishing lime and the other half on mason's hydrate with no possibility of confusion of the two products.

This two-product operation is facilitated by a dual warehouse system, which makes possible the operation of the warehouses in a single shift, while the rest of the main plant is working on a 24-hour schedule. All of the buildings are of permanent, fireproof, concrete-and-steel construction.

Compared with hydrates with a higher calcium content, the finishing lime made at Genoa has from 5 to 10 per cent more covering capacity per unit amount used in the mixture, and it minimizes the occurrence of lime pops. It is derived from a rock that occurs in massive formation without partings which admit of the presence of foreign matter. This finishing lime stocks better than ordinary lump lime and does not air-slake under average storage conditions. Its average covering capacity is about 1,000 square yards to the ton.

The plasticity referred to is a peculiar property of the hydrates from the Northwestern Ohio field. It is due to a physical, rather than a chemical difference from other limestones and because of it the demand for Northwestern Ohio finishing limes is practically national.

The United States Gypsum Company distributes these products to all centers from Denver, Colorado, east.

Work has been resumed by the Great Lakes Dredge & Dock Company on the harbor project at Buffington, Ind., for the Universal Portland Cement Company. A fleet of sandsuckers is dredging an inner basin, while piles for the docks are being driven. The harbor will be used exclusively by the cement company.

Making Alumina Cement from Ordinary Clays

A patent has just been granted Edwin C. Eckel, Washington, D. C., on a process by which alumina cement may be made from ordinary clays. It differs strikingly from all other processes ever employed, patented or suggested for use in either America or France, in that it offers a means of controlling the silica content of the raw mix so effectively that ordinary clays may be employed, and the use of bauxite as a raw material entirely omitted.

No suggestion of such a possibility appears in the previous history of the art. All the earlier processes required the use of a low-silica bauxite as one of the necessary raw materials. The cost of manufacturing the high alumina cement by the new process has been estimated at less than 50 cents a barrel, in any great industrial center. A copy of the patent application, on the basis of which the patent was secured, reads as follows:

A difficulty in the earlier alumina cement processes invented by Jules Bied (patented as Lafarge French No. 390290, Daher, U. S. No. 1004380 and Mellersh-Jackson, British No. 8675 of 1909), and by E. C. Eckel, patented as U. S. No. 1536381 and No. 1536382 arises from the fact that the treatments involved in those processes do not effect any reduction in the silica of the charge, so that in order to produce an alumina cement low in silica (which is desirable) it is necessary to start with very low-silica raw materials. In the process now described this difficulty is obviated by carrying out the fusion in a strongly reducing atmosphere and in the presence of sufficient free carbon to reduce to the metallic state not merely the bulk of the iron oxide present in the raw materials, but also such portion of the silica as may be desired.

In carrying out this process, a mixture of suitable raw materials, for example iron ore, limestone and bauxite—or iron ore, limestone and high alumina clays—is fused in a blast or electric furnace. Sufficient carbon is added, in the form of coke, charcoal, etc., not merely to supply the heat necessary for smelting but to reduce the iron oxide and such portion of the silica as may be desired. The two reduced metals unite in the melting zone to form ferro-silicon—which is in itself a highly valuable product—thus sharply reducing the costs of the alumina cement itself, which is made from the slag.

The raw materials possible are numerous, and may be combined in many ways. The essential features of calculating the charge are:

(1) That the lime and alumina present must be in such relative proportions that the chemical compound $5CaO, 3Al_2O_3$ may be formed.

(2) That, over and above any carbon required for smelting, there be added sufficient free carbon to reduce the iron oxide and silica to such extent that not over 5 per cent of ferrous oxide and not over 15 per cent of silica remain in the slag.

(3) That there must be sufficient iron present, relative to the silica to be reduced, so that the economic formation of ferro-silicon (or of a high-silicon pig) is possible. For blast furnace use such an economic ferro-silicon may carry from 10 to 25 per cent of silicon with from 90 to 75 per cent metallic iron; while if the electric furnace be employed the ferro-silicon may economically carry as much as 25 to 45 per cent of silicon as against 75 per cent to 55 per cent of iron.

By use of the process herein described, it is technically and economically possible to utilize bauxites high in silica, as well as other highly siliceous materials not heretofore employed such as siliceous diaspore clays, and even clays

(Concluded on page 110)

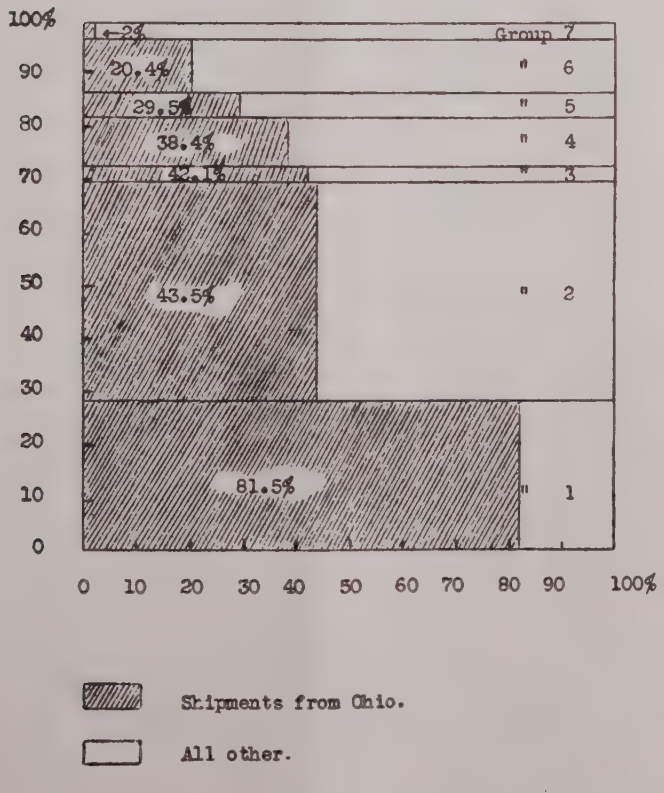
Distribution of Domestic Hydrated Lime

Producers of hydrated lime shipped into the various states of continental United States 1,312,019 tons of hydrated lime during 1924, according to a report just made by the Bureau of Mines, Department of Commerce. Of this amount 652,731 tons, or one-half, was produced in Ohio. Since so large a part of the total shipments came from Ohio plants it is of interest to compare the distribution of the Ohio product with that of the United States as a whole. Publication of comparative figures of shipments into individual states is not permissible, as it would tend to disclose items regarding distributions by individuals. The tables below are therefore presented for seven blocks of contiguous states which roughly comprise the freight rate groups.

State group[1]	From all plants		From Ohio plants		
	Short tons	Per cent distribution	Short tons	Per cent distribution	Per cent of total to group
1	377,979	28.81	308,052	47.19	81.50
2	539,702	41.14	234,632	35.95	43.47
3	35,836	2.73	15,073	2.31	42.06
4	125,814	9.59	48,328	7.40	38.41
5	65,141	4.96	19,225	2.95	29.61
6	130,631	9.96	26,664	4.08	20.41
7	36,916	2.81	757	.12	2.06
	1,312,019	100.00	652,731	100.00	49.75

1/
1. Ill., Ind., Mich., Ohio
2. Del., Dist. of Col., Md., N.J., N.Y., Pa., W.Va.
3. Conn., Me., Mass., N.H., R.I., Vt.
4. Fla., Ga., N.C., S.C., Va.
5. Ala., Ky., La., Miss., Tenn.
6. Ark., Ia., Kans., Minn., Mo., Nebr., Okla., Tex., Wis.
7. Ariz., Calif., Col., Idaho, Mont., Nev., N.Mex., N.Dak., Oreg., S.Dak., Utah, Wash., Wyo.

DISTRIBUTION OF HYDRATED LIME, 1924.



Magnesite Producers Want Tariff Protection

WASHINGTON, D. C.—The Tariff Commission heard the plea of domestic manufacturers of magnesite on June 21 for increased tariff protection. The domestic producers request an increase of 50 per cent in the duty, the maximum permitted under Section 315 of the 1922 act. No data on domestic costs of production were presented at the hearing, witnesses declaring that this information had been presented to the commission in confidence and that they regarded their costs, together with other information bearing upon the case, as trade secrets.

J. A. Bernhard, of the Sierra Magnesite Co., San Francisco, and F. E. Schundler of Joliet, Ill., a jobber, also representing C. S. Maltby & Co., of Livermore, Calif., testified that consumption of domestic magnesite has steadily declined and that domestic producers, in order to keep their customers, must sell below cost of production. They declared that they would lose all their business to the importers if they attempted to get a price which would show a profit. According to their testimony, imports from India have inflicted the greatest injury on the domestic producers.

The manufacturers of stucco and composition flooring are the principal consumers of magnesite, according to Mr. Schundler, who said that practically all of the 17,801 short tons of magnesite imported last year went into the manufacture of these and related products. Domestic magnesite used for the same purposes did not amount to more than 16,000 to 17,000 tons, he stated. Mr. Schundler testified in some detail regarding transportation costs from the west via the Panama Canal and by rail. He informed the Tariff Commission that only 2,000 tons had been shipped east this year because of the large stocks remaining from last year's output.

Walter Gordon Merritt, counsel for the importers, made a persistent effort to elicit from the domestic producers information as to their costs, stating that the importers were ready to disclose publicly all their cost data. The importers represented at the hearing were H. A. Golwynne, Magnesite Syndicate Co., Ltd., Anglo-Grecian Magnesite Company, Innis, Speiden & Co.. Inc., and Speiden, Whitfield Company. Chairman Marvin held that the domestic producers were at liberty to withhold any information which they did not desire to make public and that they had shown the utmost willingness in presenting to the commission confidentially all data pertaining to their costs.

Importation of Cement Into Straits Settlements

There were heavy importations of cement into the Straits Settlements during 1925 for use in the new construction projects that were under way. Most of the imports came from the United Kingdom, as the construction work is largely in the hands of British firms.

Total imports increased from 86,317 tons in 1924 to 136,927 tons in 1925, the share of the United States increasing from 156 tons to 2,446. Imports from the United Kingdom were 47,933 tons, more than 30,000 tons came from western continental Europe, and most of the remainder from Japan.

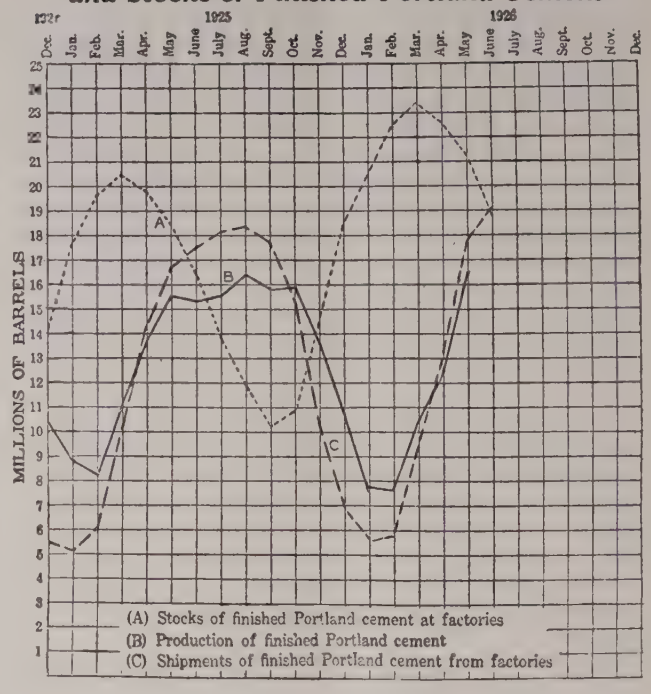
Cement Statistics for June

JUNE production and shipments of portland cement were the greatest for any month in the history of the industry, according to the Bureau of Mines, Department of Commerce. Portland cement stocks continued the seasonal decline, but at the end of June were nearly 16 per cent higher than on June 30, 1925. These statistics, prepared by the Division of Mineral Resources and Statistics of the Bureau of Mines, are compiled from reports for June, 1926, received direct from all manufacturing plants except two, for which estimates were necessary on account of lack of returns. Another new plant, located in California, is included for the first time in the statistics.

Estimated Clinker (Unground Cement) at the Mills at End of Each Month, 1925 and 1926, in Barrels

Month.	1925	1926
January	7,017,000	9,074,000
February	8,497,000	10,931,000
March	9,962,000	12,284,000
April	9,731,000	12,934,000
May	9,053,000	†11,649,000
June	7,937,000	10,088,000
July	6,961,000	
August	5,640,000	
September	4,561,000	
October	4,086,000	
November	5,013,000	
December	6,469,000	

Monthly Fluctuations in Production, Shipments and Stocks of Finished Portland Cement


1924
1925
1926
Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
MILLIONS OF BARRELS
A
B
C
(A) Stocks of finished Portland cement at factories
(B) Production of finished Portland cement
(C) Shipments of finished Portland cement from factories

Production, Shipments and Stocks of Finished Portland Cement, by Months and by Districts

Month	Production 1925	Production 1926	Shipments 1925	Shipments 1926	Stocks at end of month 1925	Stocks at end of month 1926
January	8,856,000	7,887,000	5,162,000	5,672,000	17,656,000	20,582,000
February	8,255,000	7,731,000	6,015,000	5,820,000	19,897,000	22,384,000
March	11,034,000	10,355,000	10,279,000	9,539,000	20,469,000	23,200,000
First quarter	28,145,000	25,973,000	21,456,000	21,031,000		
April	13,807,000	12,401,000	14,394,000	12,961,000	19,882,000	22,640,000
May	15,503,000	†16,472,000	16,735,000	†17,951,000	18,440,000	†21,173,000
June	15,387,000	16,827,000	17,501,000	19,013,000	16,409,000	18,987,000
Second quarter	44,697,000	45,700,000	48,630,000	49,925,000		
July	15,641,000		18,131,000		13,896,000	
August	16,419,000		18,383,000		11,952,000	
September	15,939,000		17,711,000		10,247,000	
Third quarter	47,999,000		54,225,000			
October	15,992,000		15,309,000		10,979,000	
November	13,656,000		10,187,000		14,534,000	
December	10,713,000		6,917,000		18,365,000	
Fourth quarter	40,361,000		32,413,000			
	161,202,000		156,724,000			

†Revised.

Commercial District—	Production—June 1925	Production—June 1926	Shipments—June 1925	Shipments—June 1926	Stocks at end of June 1925	Stocks at end of June 1926	Stocks at end of May, 1926†
Eastern Pa., N. J. & Md	3,554,000	3,956,000	4,340,000	4,629,000	3,321,000	3,957,000	4,629,000
New York	809,000	890,000	936,000	1,081,000	985,000	1,227,000	1,418,000
Ohio, Western Pa. & W. Va	1,587,000	1,616,000	1,839,000	2,007,000	1,735,000	2,226,000	2,617,000
Michigan	1,140,000	1,430,000	1,320,000	1,614,000	1,065,000	1,731,000	1,915,000
Wis., Ill., Ind. & Ky	2,441,000	2,407,000	2,553,000	2,896,000	3,106,000	2,964,000	3,454,000
Va., Tenn., Ala. & Ga	1,176,000	1,468,000	1,369,000	1,411,000	410,000	1,125,000	1,068,000
Eastern Mo., Ia., Minn. & S. Dak	1,461,000	1,545,000	1,720,000	1,846,000	2,808,000	2,517,000	2,819,000
Western Mo., Neb., Kan. & Okla	1,147,000	1,129,000	1,095,000	1,105,000	1,615,000	1,454,000	1,430,000
Texas	389,000	416,000	444,000	454,000	241,000	478,000	515,000
California	1,073,000	1,281,000	1,123,000	1,305,000	451,000	502,000	526,000
Colo. and Utah	216,000	689,000	221,000	665,000	343,000	806,000	782,000
Ore., Wash. & Mont	394,000		491,000		329,000		
	15,387,000	16,827,000	17,501,000	19,013,000	16,409,000	18,987,000	21,173,000

†Revised.

Mill Equipment

A New Magnetic Separator

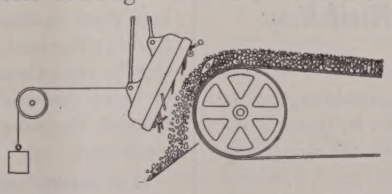
The accompanying illustration shows one method of mounting the E C & M separator magnet for removing tramp iron from raw materials before it has passed into equipment where it would cause damage and delay. It is recommended by the manufacturers, the Electric Controller & Mfg. Co., Cleveland, O., that the separator be mounted in cement mills at the crushing rolls.

It is stated that among the manufacturers of cement and limestone products, the popular method of using a separator magnet is to suspend it directly above the belt conveyor on which the products in process are carried. As crushed limestone, coal cinders, clinkers, etc., are fairly light and uniform in size, these conveyors can be loaded in a thin layer. Large quantities are moved as conveyors so loaded can be speeded up considerably without decreasing the effectiveness of the separator magnets.

It is recommended that a more effective arrangement is to suspend the magnet from a small trolley on an I-beam so that it can be moved away from the belt to discharge its accumulated load of iron. Another very satisfactory arrangement is where the magnet is suspended from a pivoted jib. The magnet is swung to one side at regular intervals, the magnet switch opened and the load is dropped into wheelbarrows. There are turnbuckles in the rods supporting the magnet. These are used to adjust the distance between the magnet and the belt and they also permit of adjusting the angle of the magnet so as to bring its face parallel to the belt and thus secure the maximum efficiency from the installation.

Direct current is required for energizing separator magnets so where only alternating current is available, small motor-generator sets are installed. One set may be used to operate a number of magnets or motor-generator sets of smaller size, each capable of supplying just enough current for one magnet, may be installed close to each separator installation. This latter method of supplying power has the advantage that no long direct current power lines need be run to those out-of-the-way spots in which separator magnets are often installed.

The illustration shows the method of mounting the separator magnet at the point where the belt has changed from a troughed to a flat condition and the material is more spread out. As the material starts to fall from the belt it is loosened and broken apart, thus tending to free any pieces of iron which may have been lodged under lumps of the conveyed material. Being at an angle, the face of the magnet is tangent to the path of the material as it falls, and so presents its greatest working area to the ore stream.



An installation of E C & M separator magnet with face parallel to the stream of material leaving the belt.

The Cecil R. Lambert Company, Inc., of Detroit—specialists in the design, manufacture and installation of conveying and handling equipment—announces that in order to identify its products and service with its name, that the latter has been changed to MECHANICAL HANDLING SYSTEMS, INC. The company's facilities for service are being materially increased.

Messiter Conveyor Scales

The Stearns Conveyor Company of Cleveland are the General Agents for Messiter Conveyor Scales. Interesting features are claimed for this scale and at least four of them are already known to be in service in cement plants.

The Messiter Conveyor Scale is described as a permanently accurate device for weighing and recording the quantity of material carried over a conveyor. They are not a new piece of equipment. They can be operated on any type of belt, bucket, apron or pan conveyor in which it is possible to suspend the conveyor track.

The Messiter scale consists essentially of a short intermediate section of conveyor track suspended from scale-beams mounted in a heavy steel frame in such a manner as to continuously weigh the material and to record the weight electrically at any desired point. The loaded and the return strands of the conveyor are separately and independently weighed and the tare weight thus obtained is automatically deducted so that only the net weight of the material is recorded.

Weights are registered entirely by means of electrical devices. A small electric generator, operated from the foot shaft produces a current at a voltage directly proportional to the speed of the belt. The current is modified by the reaction of the scale-beams, producing movement of a plunger in a mercury dashpot. This modified current directly actuates the recording device. The product of the voltage and current is therefore directly proportional to the weight of the material conveyed.

With the Manufacturers

The Jeffrey Manufacturing Company, of Columbus, Ohio, announces the election of Robert W. Gillispie as Vice President, Assistant General Manager, and member of the Board of Directors.

Mr. Gillispie has for many years been identified with the Bethlehem Steel Company and is a prominent and outstanding figure in the executive sales work of that company. He was graduated from Wesleyan University, Connecticut, in the Class of 1904, with Phi Beta Kappa rank, was an athlete and captain of the varsity football team.

The Jeffrey Manufacturing Company is well known as the oldest and largest manufacturer of coal mining machinery in the United States and makes not only coal cutting machinery, locomotives, and other mine equipment, including coal tipples, but is extensively engaged in broad engineering installations and in the manufacture of unit machinery for material handling in numerous lines.

Through the variety of its output it has been associated with practically all branches of basic industry and has a large foreign as well as domestic market.

Mr. Gillispie goes to the Jeffrey Company equipped with ripe experience in manufacturing and selling, and should prove an effective addition to the company's staff.

Mr. B. M. Horter, formerly of the Philadelphia office of the Cutler-Hammer Mfg. Co., has just been appointed manager of the company's Boston office. He succeeds Mr. J. M. Fernald, who has resigned to enter a different field of business.

Mr. Horter has been with the Cutler-Hammer Mfg. Co. since March, 1916. He started as office boy and has worked himself up through his sheer grit and determination to succeed. At one time, Mr. Horter was manager of the Wilkes-Barre office of Cutler-Hammer, which has since been discontinued.

During the war, Mr. Horter served on a submarine chaser.

Mr. Horter's technical ability makes him particularly fitted for the important post which he assumes July 1st.

MEN and MILLS

Notes from the Field

Ross Island Sand Company Buys Control of Beaver Portland Cement Co.

The Ross Island Sand and Gravel Company of Portland, Ore., has purchased control of the Beaver Portland Cement Company of Portland and Gold Hill, Ore., for a reported consideration of $850,000.

D. L. Carpenter, president of the Beaver Portland Cement Company, was elected president of the Ross Island Sand and Gravel Company also. Although the two companies will maintain their corporate entities, their management, sales activities and distributing organizations will be joined with the object of securing lower operating costs and adding to the convenience of sales and deliveries of sand, gravel and cement in the territories they serve.

The Beaver Portland Cement Company owns large deposits of raw materials for the production of cement and lime in southern Oregon. Its last financial statement shows that it has total assets of approximately $2,000,000. The Ross Island Sand and Gravel Company owns Ross Island, with an area of 150 acres and other adjacent property in the Willamette River totalling 400 acres. Approximately $300,000 will be spent by the company in the near future for developing the sand and gravel deposits on a more extensive scale.

The directorate that will now control both of these organizations is as follows: D. L. Carpenter, president; Harold Blake, vice president in charge of Ross Island operations; W. H. Muirhead, vice president in charge of production for the Beaver Portland Cement Company; Jay Bowerman, J. O. Elrod, F. T. Griffith, R. W. Hagood, Ross Hammond, G. M. McDowell, R. H. Schneeloch and C. H. Wheeler are directors of the corporation.

Dixie Portland Cement Company Reported in Merger

It is reported that the Dixie Portland Cement Company of Chattanooga, Tenn., is involved in a big merger of seven of the leading cement companies of the nation.

According to the reports, the plant of the company is to be purchased for a consideration between $7,000,000 and $8,000,000.

Federal Cement Plant Now Under Construction

Rapid progress is being made in the construction of the new plant of the Federal Portland Cement Company, now being erected near Woodlawn, N. Y. The plant is designed for an initial annual capacity of 1,000,000 barrels. Provisions are made for future increases in production up to 3,000,000 barrels annually.

The new plant is so situated that shipments of cement can be made by water, rail or truck. The company plans to have silo storage and packing houses in various parts of the city so as to cut down local hauls.

The company is financed and backed by the Buffalo Slag Company and its allied company, the Standard Slag Company of Youngstown, Ohio. Mr. L. A. Beeghly, of Youngston, Ohio, is president of the new company and Mr. J. G. Harding is general manager.

Cumberland Portland Cement Company Begins Construction

Construction has been started on the new cement plant of the Cumberland Portland Cement Company at Cowan, Tenn. Contracts for special machinery have been awarded to the Allis-Chalmers Manufacturing Company, Milwaukee, Wis. W. V. Davidson is president of the company.

Lehigh Valley Consolidation Made

Two Dexter Plants and Pennsylvania Plant Join in $40,000,000 Merger

A $40,000,000 cement mill consolidation involving mills in Northampton County, Pa., has been consummated.

The companies involved are the Dexter Portland Cement Company, Nazareth, Pa.; the Pennsylvania Portland Cement Company, Bath, Pa., and the Clinchfield Portland Cement Corporation, Kingsport, Tenn. Five plants are included: The original plant of the Dexter company, the plant of the Phoenix company recently acquired by the Dexter company, the Pennsylvania company plant at Bath, Pa., the Pennsylvania company plant near Ithaca, N. Y., and the Clinchfield plant No. 2 at Perry, Ga.

John A. Miller, of Nazareth, Pa., president of the Dexter Portland Cement Company, is scheduled to be the head of the consolidated company with offices in New York.

The combined output of all the mills in the deal will be 10,000,000 barrels of cement annually.

Vulcanite Company Dedicates New Office Building to John B. Lober

Impressive ceremonies marked the cornerstone laying at the new office building of the Vulcanite Portland Cement Company at its plant near Phillipsburg, N. J., which is being constructed as a memorial to the late John B. Lober, former president of the company. Officials and employes of the company were present.

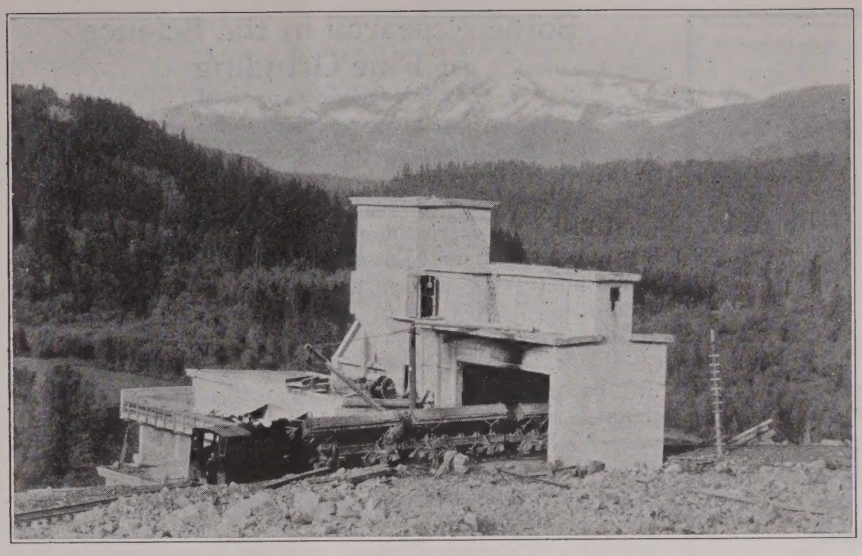
William H. Walters of Phillipsburg and Rev. Szabo of Alpha delivered addresses, while Marion Winters, granddaughter of General Superintendent W. R. Dunn, christened the cornerstone with the words, "In honor of the late John B. Lober, president of the Vulcanite Portland Cement Company."

The new office building will be of concrete and steel construction and is designed to be one of the finest plant office buildings in the Lehigh Valley.

P. C. A. Conservation Bureau Employs C. E. Barie

S. H. Dewson, for the past four and a half years assistant engineer, Conservation Bureau, Portland Cement Association, left the Portland Cement Association on July 1 to enter the employ of the Pennsylvania Cement Company at Bath, Pa., as plant engineer.

C. E. Barie, formerly chief chemist of the Indiana Portland Cement Company at Greencastle, Ind., succeeds Mr. Dewson. By reason of his wide experience in the industry as chemical engineer, Mr. Barie brings outstanding qualifications to his new position.



Rising from the Baker River, in the Skagit Range of the Cascade Mountains, is a high limestone bluff. Here, about a mile and a half from the mill, is the picturesque quarry of the Superior Portland Cement Company. About 1400 tons of rock are supplied daily from a face of limestone 1000 feet long and from 180 feet to 230 feet high. Twelve yard dump cars haul the rock to the crusher house shown in the illustration.

F. B. Franks Heads New Cement Company

A charter of incorporation was granted at Harrisburg, Pa., to the Keystone Portland Cement Company, Bath, Pa., capital, $10,000, Judge E. J. Fox, Easton Trust Company, treasurer.

The plant will be located between Bath and the present Bath Portland Cement Company's mill. Fred B. Franks, former superintendent of the Bath Portland Cement Company, is promoting the venture and will be at the head of the concern when operations begin.

The Keystone Portland Cement Company has purchased four big farms near Bath on which the plant will be erected. It is reported that work on the construction of the plant will begin shortly.

Good Accident Record

At the regular semi-annual meeting of the accident prevention committee of the Nazareth Cement Company, the benefits of accident prevention work were cited by Richard Lounsbury, superintendent. The important fact that for 75 consecutive days there was not an accident in the mill or shops of the plant and that for 146 consecutive days no time was lost through accidents, was cited as a direct result of this work.

The plant was divided into three sections for accident prevention—the mill, the quarry and the machine sections. Each section will float a flag from a staff and the section in which an accident occurs will be compelled to lower the flag to half mast. Officials of the company are cooperating in every manner possible to make the plant as free from accidents as possible.

Dixie Company Adds Two New Kilns

W. H. Klein, general superintendent of the Dixie Portland Cement Company, Richard City, Tenn., announces that the two new kilns, 11 feet 3 inches and 10 feet in diameter, 243 feet long, will be installed at the present plant at Richard City. The kilns and kiln machinery were purchased from Reeves Brothers and will be equipped with F. L. Smidth & Co., Unax coolers.

Improvements Under Way at Plant of St. Joe Lime and Cement Co.

Work is under way at the St. Joe Lime and Cement Company plant at St. Joe, Ark., on the construction of a new hydrating plant. Other improvements include the electrification of the entire plant and the installation of a new kiln. It is estimated that when these new improvements are completed, on September 1, the capacity of the plant will be trebled.

Moore Is New Testing Engineer for Universal Co.

O. L. Moore, formerly engineer, Inspection Bureau, Universal Portland Cement Co., has been appointed to the position of engineer of tests in that company, according to an announcement from the Chicago office of the Universal company. Mr. Moore is a graduate of Carnegie Institute of Technology and a member of the American Society for Testing Materials, American Concrete Institute and Western Society of Engineers. He has been connected with the Universal Portland Cement Co. for the last 12 years.

President Tyler Reports Progress on New Dewey Plant

In a report to CONCRETE President F. E. Tyler of the Dewey Portland Cement Company reports that splendid progress is being made in the construction of the company's new plant at Davenport, Iowa. J. C. Buckbee Company of Chicago are the engineers.

Contracts for the construction of this plant were let on June 16. The major part of machinery purchases have been made, consisting of those made with the Allis-Chalmers Company, the General Electric Company, the Bucyrus Company and many other smaller ones covering travelling cranes and other equipment.

The general construction contract covering foundations and buildings was let to the Priester Construction Company of Davenport. The contract for the cement storage bins was awarded to the Jones-Hattelsater Construction Company of Kansas City, Mo.

Work is going ahead at a satisfactory rate. Two lines of railroad tracks are already across the ground and the third will soon be completed. Excavations for the sewerage system as well as excavations for the foundations and buildings are rapidly being made. Concreting has been started.

Cement Steamer Plys Lakes

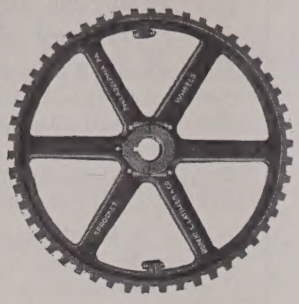
The steamer John W. Boardman, in command of Captain D. McLachlin, delivered 26,000 barrels of cement in Duluth for the Huron Portland Cement Company. The arrival of the vessel at Duluth, Minn., marked her first trip to the head of the lakes since she was commissioned a year ago.

The deck arrangements of the steamer are unique in that there are no hatches on deck and loading and unloading is accomplished by a self-unloading device capable of handling 26,000 barrels of cement in 12 hours. The Boardman is an all-steel vessel of 4,011 tons, 334 feet long, 55 foot beam and 28 foot draft. She was built in Toledo in 1923 and is owned by the Huron Transportation Company of Marine City, Mich. While there are several self-unloading coal boats on the Great Lakes, the Boardman is the first vessel to be built and equipped for handling cement exclusively.

Directors Meet

At a meeting of the board of directors of the New Egyptian Portland Cement Company held in Detroit, the regular quarterly dividend of 1¾ per cent was declared on the 7 per cent preferred stock and the regular quarterly dividend of 40 cents per share on the common stock, to stock of record June 19, 1926, payable July 1, 1926.

The company reports very favorable conditions both as to production and shipments.



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Some Research in the Science of Fine Grinding

(Concluded from page 97)

mill is composed of homogeneous grades of crushed sand, in which the distribution of the numbers of the particles with their diameters cannot be altered, no matter how often we regrade the sand.

These statistically homogeneous grades of sand may be considered as the unalterable elements which compose a given mixture of sand particles. In such an homogeneous grade the distribution of the particles follows the probability law.

This was proved by separating out the sand coming from a tube-mill (and whose particles followed the compound interest law $N = a\,e^{-bx}$) into separate grades by repeated air elutriation. One of these grades was then elutriated some 8 or 9 times without in any way altering the distribution of particles therein, which was found to follow the probability law : $N = a\,e^{-bx^2}$, where N is the number of particles of a given diameter x; a and b are constants.

This law is also probably a mathematical consequence of Rittinger's law and the compound interest law. The laws regulating particle size are established by this research.

*G. Martin and others, Trans. Ceram. Soc., 1925-6, **25**, 51, 63.
†G. Martin, C. E. Blyth, and H. Tongue, Trans. Ceram. Soc., 1923-24, **23**.

Making Alumina Cement from Ordinary Clays

(Concluded from page 104)

of the type of kaolinite and halloysite, heretofore unusable by any process ever employed or even suggested for use. An incidental advantage is that the presence of the high percentages of iron and of free or excess carbon makes it easily possible to produce fused lime-alumina cements whose essential component is the compound $5CaO,3Al_2O_3$, giving higher strengths and greater durability than the mono-calcic compounds previously employed in the Daher, Mellersh-Jackson and Lafarge processes.

The presence of unreduced silica results in the formation of a relatively small amount of lime silicate in the cement slag; and at times a still smaller percentage of ferrous silicate is similarly produced, whereby the resulting cement composition will be approximately

$$6CaO,3Al_2O_3,\ SiO_2$$

or

$$6CaO,3Al_2O_3,2SiO_2,FeO$$

I claim:

1. The process of making alumina cement and ferro-silicon by the fusion of a mixture of raw materials containing alumina, iron oxide, silica and lime, in the presence of sufficient free carbon to reduce most of the iron and sufficient of the silicon so that the resulting slag will be of the approximate chemical formula $6CaO,3Al_2O_3,SiO_2$; separating the ferro-silicon and the slag; and cooling and grinding the latter to cement.

2. The process of making cement and ferro-silicon comprising the fusion of a mixture of materials containing alumina, iron, silica and lime, in the presence of sufficient free carbon to form ferro-silicon.

3. The process of making cement and ferro-silicon comprising the fusion of a cement forming mixture containing iron and silica in the presence of sufficient free carbon to form commercial ferro-silicon and cement slag.

4. The process of making cement and ferro-silicon comprising the fusion of a cement forming mixture containing iron and silica in the presence of sufficient free carbon to form high-silicon pig iron and cement slag.